Analysis of Economic Variables on Carbon Emissions in ASEAN Countries 2010-2021

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Abstract

Environmental degradation is an increasing problem for countries around the world, especially in the ASEAN region. The first research conducted with the EKC hypothesis was carried out by Grosman & Krueger in 1991, which supported the EKC claim that environmental degradation and economic growth are interconnected. This research aims to analyze the determinants of carbon emissions in ASEAN member countries in 2010-2021 with the variables GDP, population, foreign direct investment, and renewable energy consumption on carbon emissions. This research uses secondary data obtained from the World Bank and International Energy Agency websites. The data analysis method uses panel data regression with the Fixed Effect Model (FEM) approach and Stata 14 analysis tools. The results of the research show that the EKC hypothesis is not proven because GDP does not have a significant effect on emissions, while the population variable has a significant positive effect on carbon emissions. then the FDI variable has no influence on the carbon emissions variable and the REC variable has a significant negative influence on carbon emissions.

Keywords: EKC, Emissions, GDP, Population, FDI

Abstrak

Degradasi lingkungan merupakan masalah yang semakin besar bagi negara-negara di seluruh dunia, khususnya di kawasan ASEAN. Penelitian pertama yang dilakukan dengan hipotesis EKC dilakukan oleh Grosman & Krueger pada tahun 1991, yang mendukung klaim EKC bahwa degradasi lingkungan dan ekonomi pertumbuhan saling berhubungan. Penelitian ini bertujuan untuk menganalisis determinan emisi karbon di negara Anggota ASEAN pada tahun 2010-2021 dengan variabel GDP, populasi penduduk, investasi asing langsung, dan konsumsi energi terbarukan terhadap emisi karbon. Penelitian ini menggunakan data sekunder yang diperoleh dari website World Bank dan International Energy Agency. Metode analisis data menggunakan regresi data panel dengan pendekatan Fixed Effct Model (FEM) dan alat bantu analisis stata 14. Hasil penelitian menunjukkan bahwa hipotesis EKC tidak terbukti karena GDP tidak berpengaruh signifikan terhadap emisi, sedangkan variabel populasi penduduk memiliki pengaruh positif signifikan terhadap emisi karbon, kemudian variabel FDI tidak memiliki pengaruh terhadap variabel emisi karbon dan untuk variabel REC memiliki pengaruh negatif signifikan terhadap emisi karbon.

Kata Kunci: EKC, Emisi, GDP, Polulasi, FDI

INTRODUCTION

Environmental degradation is an increasing problem for countries around the world, especially in the ASEAN region. The first research conducted with the EKC hypothesis was carried out by Grosman & Krueger in 1991, which supported the EKC claim that environmental degradation and economic growth are interconnected. This research aims to analyze the determinants of carbon emissions in ASEAN member countries in 2010-2021 with the variables GDP, population, foreign direct investment, and renewable energy consumption on carbon emissions. This research uses secondary data obtained from the World Bank and International Energy Agency websites. The data analysis method uses panel data regression with the Fixed Effect Model (FEM) approach and Stata 14 analysis tools. The results of the research show that the EKC hypothesis is not proven because GDP does not have a significant effect on emissions, while the population variable has a significant positive effect on carbon emissions. then the FDI variable has no influence on the carbon emissions variable and the REC variable has a significant negative influence on carbon emissions.

Rising greenhouse gas emissions are a major driver of climate change. The majority of greenhouse gas emissions come from carbon dioxide (CO_2), which is the most powerful of the six gases that according to scientists contribute to global warming. One of the human activities that contributes to the emergence of CO_2 gas is economic growth (Pratama, 2022). There is a trade-off relationship between the environment and economic development, according to some scientists. Thus, environmental damage and resource scarcity will accompany rapid economic expansion, giving rise to negative impacts on the environment (Faizah et al., 2021).

Development becomes unsustainable if the focus is only on achieving high economic growth. In the process of encouraging high growth rates, neglect of environmental aspects causes a decline in environmental quality. Low environmental quality, especially air pollution, causes decreased health. Principles of sustainable development with national policies and programs and restoring lost environmental resources (Zulaicha et al., 2018). One of the indicators used to measure the success of this target is the amount of CO_2 emissions. This means that the government must implement sustainable development to ensure environmental sustainability now and in the future(Santi & Sasana, 2021). Furthermore, the research is also to examine the differences in the influence that economic growth, population, foreign direct investment, and renewable energy consumption have on CO_2 emissions.

According to Mankiw (2018) CO_2 or carbon dioxide, the burning of fossil fuels produced by human activities, is a greenhouse gas such as coal, petroleum and natural gas. Then what contributes to global warming and climate change is carbon dioxide emissions. In his book entitled "Principles of Economics," Mankiw explains that CO_2 emissions are an example of a negative externality from production and will have a negative impact on the environment and human health from the consumption of various goods and services.

The Environmental Kuznets Curve (EKC) is an inverted U-shaped theory that shows the relationship between economic expansion and environmental degradation. Kuznets' theory in 1991 was the first to propose the EKC hypothesis. Environmental damage, according to this theory and the EKC hypothesis, will increase with economic growth. However, there will be a turning point where the relationship between the two will begin to improve, thus leading to a better environmental condition(Cristy & Sakti, 2022).
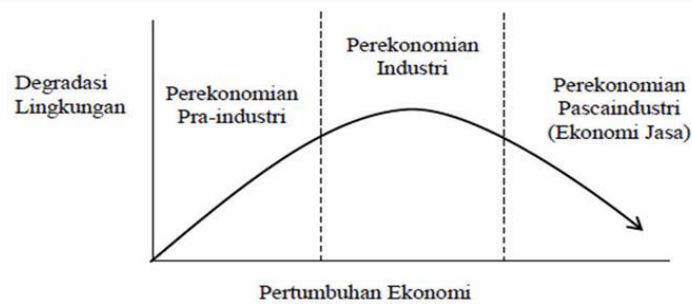
Image 1
Environmental Kuznets Curve (EKC)
(Source: Shaharir & Alinor, 2013)

The EKC hypothesis explains that economic growth will initially increase environmental degradation. This is because the country will focus on increasing production without paying attention to environmental aspects. Continuous production processes will then result in environmental degradation in the form of pollution of land, water and air. Economic growth at a certain point will then make people aware that the need for good environmental quality is very important (Nikensari et al., 2019).

CONCEPT AND HYPOTHESIS
The Effect of GDP on CO2 Emissions

Research (A'yun & Khasanah, 2022), provides analysis results that economic growth has a positive effect on CO2 emissions. This proves that increasing GDP will also increase CO2 emissions. The increase in CO2 emissions is caused by household consumption expenditure and government consumption. To increase GDP, the government focuses on implementing policies to improve people's welfare. Through the policies implemented, the government can increase state income through taxes as well as community welfare, reducing unemployment, poverty and encouraging economic growth. Research by (Prasetyanto & Sari, 2021) and (Alam et al., 2016) also shows that GDP has a significant positive effect on CO2 emissions in the long term as well as in the short term.
H: The GDP variable has a significant positive effect on CO2 emissions.

Effect of GDP2 on CO2 Emissions

With the squared GDP variable having a significant negative value, it will indicate that CO2 emissions are an effect of economic development, where as economic development continues and environmental damage or CO2 emissions will decrease. This means that in the long term it is possible that CO2 emissions in ASEAN countries will decrease along with increasing GDP. In research by (Prasetyanto & Sari, 2021) and (Alam et al., 2016) it is clear that GDP squared has a significant negative effect on CO2 emissions in the long term as well as the short term.
H: The quadratic GDP variable has a significant negative effect on CO2 emissions.

Influence of Population on CO2 Emissions

The population size also triggers a lack of green open space and people are less aware of environmental pollution so that the population size has a large influence on CO2 emissions. According to research (Wafiq & Suryanto, 2021) the results show that the correlation between economic growth and population density on environmental quality is moderate. He has a significant negative impact on environmental quality. This is also influenced by the quantity of the population which causes increasing carbon dioxide emissions in a country. The level of education and awareness of city residents in their behavior in daily activities will influence their environment.
H: Population has a positive and significant influence on carbon dioxide emissions.

The Effect of Foreign Direct Investment on CO2 Emissions

Foreign Direct Investment is a type of foreign direct investment and capital investment that can cause environmental degradation. This is because FDI can be a way of outsourcing or dirty industry from more developed countries to less developed countries (Santi & Sasana, 2021). Poor environmental policies have caused several industries with high levels of contamination and high levels of consumption to move from other countries, resulting in a large increase in carbon pollution. FDI hereby produces negative externalities for the host country (Rizki & Anggaeni, 2022).

H: There is a positive influence between foreign direct investment on carbon dioxide emissions

The Effect of Renewable Energy Consumption on CO2 Emissions

The use of fossil fuels continues to increase globally. The use of energy from fossil materials can cause environmental pollution, especially global warming. So there is a need for renewable energy to be an alternative as an environmentally friendly energy source. The development of renewable energy will become faster in the next few years, becoming a clear example of the sustainable acceleration of renewable energy to reduce global warming levels to 1.5 degrees Celsius (IEA, 2022). This statement is in accordance with the results of research conducted by (Tachega et al., 2021) where the use of renewable energy has a negative effect on carbon dioxide emissions in the long term.

H: There is a Negative Influence of Renewable Energy Consumption on Carbon Dioxide Emissions

METHOD

This research uses quantitative research methods. The method used is quantitative research where the type of data can be measured or calculated directly for numbers or numbers. What explains the problem or object of research is the science of statistics and measurement. The purpose of this method is to determine the hypothesis test that has been determined. Then the correlation method in this research is used to involve the act of collecting data as a determinant of the existence of a relationship and the level of relationship between two or more variables.

There is a carbon dioxide emission variable as a dependent variable or Y and an independent variable or X, namely GDP, GDP2, population, FDI, and REC. These variables are used in this research and use data starting from 2010-2021, and the data is obtained from the World Development Indicator (World Bank, 2022). This study obtained 5 variables where data source information was obtained through the official and accurate website of the World Development Indocator (World Bank), (https://databank.worldbank.org/source/world-development-indicators) and the International Energy Agency (https://www.iea.org/data-and-statistics/data-tools/greenhouse-gas-emissions-from-energy-data-explorer).

Panel data consists of time series and unit series (cross sections) which have been combined. This research uses a cross section of 11 countries in ASEAN and a time series from 2010-2021. An illustration of a panel data regression model using cross-section data is:

$CO2_{it} = \beta_0 + \beta_1 GDP_{it} + \beta_2 GDP2_{it} + \beta_3 PENDUDUK_{it} + \beta_4 FDI_{it} + \beta_5 REC_{it} + \varepsilon_{it}$

Keterangan:

CO2	= CO2 greenhouse gas emissions (metric tons)
GDP	= Gross domestic product (US$)
GDP2	= Kuadrat gross domestic product (US$)
PENDUDUK	= The population of a country (jiwa)
FDI	= Foreign Direct Investment (US$)
REC	= Renewable Energy Consumtion (%)
i	= 11 ASEAN countries
t	= Period 2010-2021

ε	= Error team

RESULT AND DISCUSSION

The results of statistical analysis of the variables are presented in the following table. To provide data results intended to answer the researcher's questions, this analysis is used in the research model.

Tabel 1 *Hasil Summary Data Panel*

Variabel	Mean	Std. Dev	Min	Max
Emisi CO_2 (Y)	17.48945	2.006802	12.88844	6.59e+08
GDP (X1)	11503.03	11503.03	765.2419	77710.07
GDP2 (X2)	4.62e+08	1.11e+09	585595.1	6.04e+09
Populasi Penduduk (X3)	16.72978	1.912157	12.8893	19.42774
FDI (X4)	1.385808	0.9072769	-1.102868	3.552456
REC (X5)	28.71689	23.51931	0	84.93

(Source: Stata 14 data processing results, data compiled)

Based on the descriptive statistics of the variables used in the research model according to the table above, the descriptive analysis for each variable includes the following: This study used 132 observations and it can be seen that the average CO2 emissions during the 2010-2021 time period were 17.48945 million tons with a standard deviation of 2.006802 million tons. The lowest CO2 emissions were 12.88844 million tons and the highest were 6.59e+08 million tons. The GDP variable has an average in the 2010-2021 period of 11,503.03 US dollars with a standard deviation of 11,503.03 US dollars. The lowest GDP level was 765,2419 US dollars and the highest was 77710.07 US dollars. The Quadratic GDP variable has an average in the 2010-2021 period of 4.62e+08 US dollars with a standard deviation of 1.11e+09 US dollars. The lowest GDP Square was 585595.1 US dollars and the highest was 6.04e+09 US dollars. Then the average population is 16.72978 people with a standard deviation of 1.912157 people. This variable has the lowest value of 12.8893 people and the highest value is 19.42774 people. The next variable is renewable energy consumption which has an average in the 2010-2021 time period of 28.71689 percent with a standard deviation of 23.51931 percent. The lowest renewable energy level was 0 percent and the highest was 84.93 percent.

Which panel data testing approach is most suitable for this research depends on a number of factors. This is based on analysis of the test results of three models as follows:

Tabel 2 *Hasil Summary Data Panel*

Variabel	CEM		FEM		REM	
	Coefficient	Prob.	Coefficient	Prob.	Coefficient	Prob.
GDP (X1)	0.000169	0.000	0.0000422	0.166	0.0000681	0.000
GDP2 (X2)	-2.27e-09	0.000	-4.74e-10	0.066	-7.14e-10	0.0001
Populasi Penduduk (X3)	1.153063	0.000	3.496564	0.000	1.122685	0.000
FDI (X4)	1 .13839	0.044	0.0630316	0.211	0.0620965	0.243
REC (X5)	-.0187112	0.000	-0.0223283	0.000	-0.0315977	0.000

(Source: Stata 14 data processing results, data compiled)

Based on the processed data above, it can be concluded that the results are through the Command Effect model. The GDP, FDI and population variables have a positive and significant influence on CO_2 emissions, while the GDP2 and REC variables have a negative and significant influence on CO_2 emissions. Based on the regression results of the Fixed Effect Model (FEM) Method above, it can be concluded that the variables GDP, GDP2, and FDI have no effect on the CO_2 Emission variable. The Population Population variable has a significant positive effect and the REC variable has a significant negative effect on CO_2 Emissions. Based on the results of the Random Effect Model (REM) regression in table 2 above, the GDP and Population Population variables have a significant positive effect on CO_2 Emissions, while GDP2 and REC have a significant negative effect on the variable CO_2 Emissions. Next, Model Specification Testing will be carried out using the Chow Test, Hausman Test and Lagrange Multiplier Test in order to get the best results from the panel data summary test results.

Tabel 3 Hasil Uji Chow

Test Summary	Prob.
F (10, 114) = 39.24	0.0000

(Source: Stata 14 data processing results, data compiled)

The results in the table above have a cross section F probability value greater than the significant value of 0.05, so it can be interpreted as the best choice from the Chow test results, namely the Fixed Effect Model.

Tabel 4 Hasil Uji Hausman

Test Summary	Chi-Sq. Statistic	Prob>Chi2
Cross-Section random	13.18	0.0043

(Source: Stata 14 data processing results, data compiled)

The results of the Hausman test in table 4.4 with a probability value of 0.0043 show that the probability is basically below alpha 5% or 0.05. So it can be concluded that the best test results are using the Fixed Effect Model.

Tabel 5 Hasil Uji F

F-statistic	F-tabel	Prob
29.77	2,29	0.0000

(Source: Stata 14 data processing results, data compiled)

Based on the results of the analysis, it can be concluded that the F-statistic is 29.77, which is greater than the F-table 2.29, so it can be concluded that the variables GDP (X1), GDP2 (X2), Population (X3), FDI (X4) and REC (X5). has a significant positive effect on carbon dioxide emissions in ASEAN member countries.

Tabel 6 Uji Koefisien Determinasi (R^2)

R-squared	0.7205

(Source: Stata 14 data processing results, data compiled)

Based on the table above, it can be seen that the R-squared coefficient of determination is 0.7205. These results conclude that 72.05% of Carbon dioxide Emissions (Y) can be explained by GDP (X1), GDP2 (X2), Population (X3), FDI (X4) and REC (X5). Meanwhile, the remaining 27.95% is explained by other factors outside the model.

$$CO2it = \beta 0 + \beta 1GDP\ it + \beta 2GDP2it + \beta 3PENDUDUKit + \beta 4FDIit + \beta 5RECit + \varepsilon it \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots(1)$$

$$CO2it = \beta 0 + \beta 1GDP(0.0000422)it + \beta 2GDP2(-4.74e\text{-}10)it + \beta 3PENDUDUK(3.496564)it + \beta 4FDI(0.0630316)it + \beta 5REC(-0.0223283)it + \varepsilon it \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots(2)$$

Dimana:

GDP (0.0000422) => When economic growth has no influence on greenhouse gas emissions in Asian countries.

GDP2 (-4.74e-10) => When economic growth is long term, it has no effect on greenhouse gas emissions in Asian countries.

Penduduk (3.496564) => When the population increases by 1 percent, it will increase the greenhouse gas emissions of Asian countries by 3,496564 metric tons.

FDI (0.0630316) => When foreign direct investment has no effect on greenhouse gas emissions in Asian countries.

REC (-0.0223283)=> When renewable energy consumption increases by one percent, it will reduce greenhouse gas emissions in Asian countries by 0.0223283 metric tons.

The Effect of Economic Growth (GDP and GDP2) on CO2 Emissions

The variables GDP and GDP2 have no influence on carbon dioxide emissions, meaning that if GDP increases or decreases it does not affect carbon dioxide emissions. This is inversely proportional to the research hypothesis which states that the GDP variable has a positive and significant influence on CO2 emissions and the Kuznets curve theory does not apply in this research.

This did not affect CO_2 emissions in this study. The finding (Noor & Saputra, 2020) that GDP is not related to CO2 emissions is relevant here. Economic activity in ASEAN countries is strongly driven by increased energy use, which in turn increases CO_2 emissions. However, reducing CO_2 emissions will affect economic activity. Herein lies the difficulty faced by ASEAN countries in achieving their goal of reducing CO2 emissions while encouraging economic growth. This research on ASEAN countries considers the EKC to be unrealistic due to the fact that CO2 emissions are a type of global pollution that may fluctuate and are expected to take a very long time to respond.

This is also in line with research conducted by (Lubis et al., 2023) showing that economic growth in the short term has a positive and significant effect on greenhouse gas emission variables. However, it has no impact on greenhouse gas emissions for a long time. So the Kuznets curve theory does not apply to this research. Opoku, Amoako, & Amankwa (2014) published the findings of a related study in Ghana, showing that there is a short-term equilibrium, but EKC is unproven and has no visible impact. Ali, Khatoon, Ather, & Akhtar (2015) conducted a similar study in Pakistan, which showed that there is a short-run equilibrium but did not support EKC due to the lack of significance of GDP and GDP squared. Since CO2 greenhouse gas emissions are a type of global pollution that can rise or fall and are expected to take a very long time, the EKC did not prove to be reasonable in this study or the six countries in the ASEAN region.

The Effect of Population on CO2 Emissions

The estimated value shows that the population variable has a significant positive effect on CO2 emissions. In Asian countries, CO_2 emissions will increase by 3.496564 metric tons for every one percent population growth.

According to research (Lubis et al., 2023), there is a positive correlation between increasing population, mobility and CO2 emissions in the long term. Because they are energy users, humans face great challenges in protecting the environment. Consequently, increasing population impacts carbon dioxide emissions because higher levels of per capita consumption are associated with increasing population. Zulaicha et al. (2020) found that increasing population significantly reduces CO2 emissions, therefore this also makes sense. The reason is, the more people use motorized vehicles, this ultimately increases the need for energy, especially petroleum. There is less and less green space available due to population growth, which ultimately makes people ignore air pollution. The same thing happened in the Association of Southeast Asian Nations (ASEAN), which showed positive population growth over the years, which shows that the population in this region is still growing and CO_2 emissions are also increasing.

Effect of Amount of FDI on CO2 Emissions

There is no relationship between carbon dioxide emissions and the FDI variable. This shows that changes in the level of external investment will have no effect on carbon dioxide emissions. This is contrary to the previous research hypothesis which predicted a positive and statistically significant relationship between foreign investment and carbon dioxide emissions.

A country needs investment from both within and outside the country to trigger economic growth in that country. One type of investment is Foreign Direct Investment (FDI). FDI can provide many benefits to a country's economy. Apart from the economic side, FDI can also encourage improvements in air quality in destination countries, one of which is through technology transfer. This is supported by the Pollution Halo Hypothesis.

Developing countries can benefit from foreign direct investment (FDI) in the form of technological advances that increase energy efficiency and reduce carbon dioxide emissions (Noor & Saputra, 2020). Reducing carbon dioxide emissions through the use of renewable energy sources is an environmental issue and a development success in fighting poverty throughout the world.

Effect of Renewable Energy Consumption on CO2 Emissions

Greenhouse gas emissions in Asian countries will decrease by 0.0223283 metric tons for every 1% increase in renewable energy use, according to statistics. Based on these results, switching to renewable energy sources will reduce carbon dioxide emissions. This conclusion is in line with the findings of Bilgili, Kocak, & Bulut (2015) who investigated variables related to renewable energy sources that pose a threat to CO_2 emissions. Because it produces far fewer pollutants than fossil fuels which have a negative impact on CO2 emissions, renewable energy is safe for the environment and its residents. Renewable energy sources will reduce the negative impact of environmental degradation which endangers all forms of life. The reduction in carbon dioxide emissions is associated with the increased use of renewable energy sources (Zulaicha et al., 2018).

CONCLUSION

The results of the investigation of the Environmental Kuznets Curve (EKC) hypothesis in eleven ASEAN countries show that GDP and GDP2 do not affect CO2 emissions, according to research presented in the Fixed Effect Model. In eleven ASEAN countries, this refutes the EKC theory. Fluctuating population numbers also significantly influence CO2 emissions and have beneficial impacts. The foreign investment (FDI) variable in this analysis has no effect on CO2 emissions. Based on variable

findings, the use of renewable energy sources has significantly negative carbon dioxide emissions. There are several things that can be done to reduce carbon dioxide emissions, here are some suggestions that can be done:

It would be better to overcome natural damage caused by increasing economic activity, so it would be better if economic activity used more advanced and environmentally friendly technology. Environmentally friendly technology can have an impact on reducing the amount of pollution and environmental pollution.

The role of the government is to promote and put into practice the regulations that have been made while arousing public attention to take on the task of monitoring harmony between the economy and the environment. Policies to improve renewable energy transition policies to reduce the use of fossil fuels which damage the environment and utilize economic growth as a means by allocating funds for technological research related to efforts to improve environmental quality.

Due to the limitations of this research, it is hoped that there will be further studies using other parameters. A kind of comprehensive data, there is a two-way relationship between the economy and the environment and does not only present general conclusions.

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